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AEROBALLISTIC RANGE ASSOCIATION

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of the Ames Research Center Staff

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Paper for presentation at meeting of  
Aeroballistic Range Association

NASA-Ames Research Center

THE AMES PROTOTYPE HYPERSONIC FREE-FLIGHT FACILITY

By Robert J. Carros

[1962]

Presented at the

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Facility description.- The facility described in this paper is a shock-tube-driven wind tunnel through which models are gun-launched at high velocity. A schematic diagram of the arrangement of the facility is shown in figure 1. The driver is a tube nominally 6 inches in diameter and 40 feet in length and may be charged with cold helium, cold hydrogen, or with a combustible mixture to steam-heat helium. (The process of combustion was discussed in a previous paper by Mr. Max Wilkins.) The driver tube is equipped with three piston-type strain-gage pressure transducers to measure the afterburn pressure in the case of the steam-heated helium operation. These pressure cells are located at the breech, center, and diaphragm end of the driver tube.

The shock tube has nominally the same dimensions as the driver, that is, a 6-inch diameter and a 40-foot length. There is a pressure switch located near the principal diaphragm and one located at the center of the tube for measuring the shock Mach number. A Kistler piezo pressure transducer is located near the nozzle diaphragm for measuring stagnation pressure. The maximum stagnation pressure now attainable is 700 atmospheres, corresponding to a stagnation enthalpy of 3000 Btu/lb.

The principal diaphragm is preformed from stainless steel in a hemispherical shape. A piercing mechanism which is gun-powder-driven is used to start this diaphragm to open, and the driver pressure completes the opening. The stainless steel nozzle diaphragm is flat and is prescored to open at relatively low pressure. The nozzles available, which provide free-stream air velocities of 6000, 9000, and 12,000 ft/sec, are of the convergent divergent type and are contoured for a free-stream Mach number of 7.

The test section of the facility is octagonal in cross section and the dimension across the flats of the octagon is approximately 2 feet.

Eleven stations spaced on 4-foot centers are located in the test section, and each station is equipped with an orthogonal shadowgraph system for measuring model attitude and displacement. The test section also contains photomultiplier-tube pickups for measuring broad-band radiation, and a deconvoluted unit for spectral analysis of the radiation is under design and construction. These radiation-measuring devices are discussed in detail in a subsequent paper by Mr. William Davy. Pressure transducers, also located in the test section, measure the static pressure level.

The dump tank shown in figure 1 at the downstream end of the test section is a large volume vessel into which the air is damped and kept at low pressure to prevent disturbances from propagating back into the test section. A pressure-relief valve located on top of this tank prevents the test section area from becoming overpressured. The gun presently being used in this facility is a 50-caliber deformable-piston type gun and is discussed in a preceding paper by Mr. Jack Stephenson. Maximum model velocities of 28,000 ft/sec have been achieved with this gun.

x - t wave diagram.- A schematic x - t wave diagram is shown in figure 2. Starting at time zero (the time at which the principal diaphragm opens), a shock wave proceeds down the shock tube and reflects in the manner shown. Following this incident shock wave is the gaseous interface which, when met by the reflected shock wave, is deflected in the general direction shown. Also starting at time zero an expansion wave travels back through the driver tube and is reflected from the end, as shown. By design, the air in the shock tube is exhausted at the time this reflected expansion wave reaches the stagnation region. Shown in the test section region is the starting shock wave followed by the start of flow. The theoretical testing time then is the time between the flow start and the air exhaustion (coincident with the expansion wave in this case). In actuality, this total test time is not attainable since there is mixing between the driver and driven gas at the gaseous interface. This is indicated in the figure by the shaded region. In the case of

the operation with the 12,000 ft/sec nozzle this theoretical testing time is 12 milliseconds and the actual testing time is in the order of 6 milliseconds.

Example records.- An example stagnation pressure record is shown in figure 3. The oscilloscope trace begins at the left at the initial shock-tube pressure level and rises abruptly to the stagnation pressure level. The decrease in pressure shown occurs when the reflected expansion wave reaches the stagnation region. An example free-stream static pressure record is shown in figure 4 and the oscilloscope trace is again from left to right. The first rise in pressure shows the passage of the starting shock wave and the second rise in pressure shows the flow start. The nearly level region reached on this second rise is the free-stream static pressure level. The fall in pressure corresponds with the arrival of the reflected expansion wave.

Figure 5 shows an example shadowgraph obtained in this facility of a round-nosed cone model at a velocity of 32,500 ft/sec. The facility to date has been used to obtain aerodynamic data as well as air radiation data and in the future will likely be used to obtain research data of other nature.

Operating range.- The operation range of the facility is shown in figure 6. The altitude shown on the figure is the equivalent altitude corresponding to the free-stream density obtainable in the facility. The present operating range is shown as the area bounded by the solid lines, and the anticipated range is shown as the area bounded by the dashed lines. This anticipated range may be achieved by strengthening shock-tube joints, by construction of a nozzle to provide a free-stream air velocity of 15,000 ft/sec and by development of a gun to provide model-launching velocities of 33,000 ft/sec. Also shown on this figure are trajectories of the Mercury, Apollo, and planet probe and the extent to which the present and anticipated performance covers these trajectories.

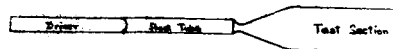
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Diagram illustrating a pump and tank system. The pump is connected to a tank. The pump has a discharge line with a valve. The tank has a liquid level. The pump is labeled "Pump" and the tank is labeled "Tank". The discharge line is labeled "Discharge Line".

Parameters for the pump and tank system:

- $H_p$  to 700 ft
- $H_s$  to 3400 ft
- $V_m = 6000$  ft/sec
- 9000 "
- 12000 "
- $M_m = 7$
- Area to 22,000 ft

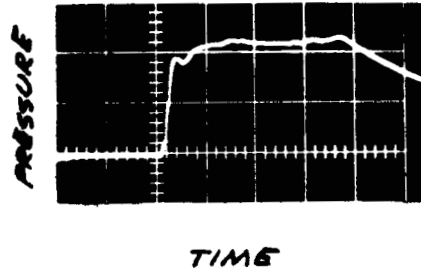
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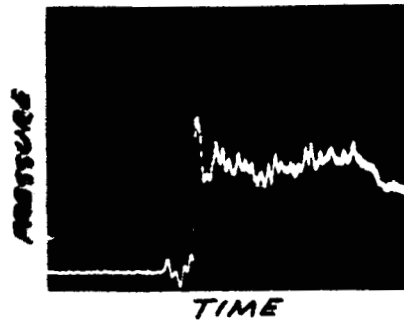
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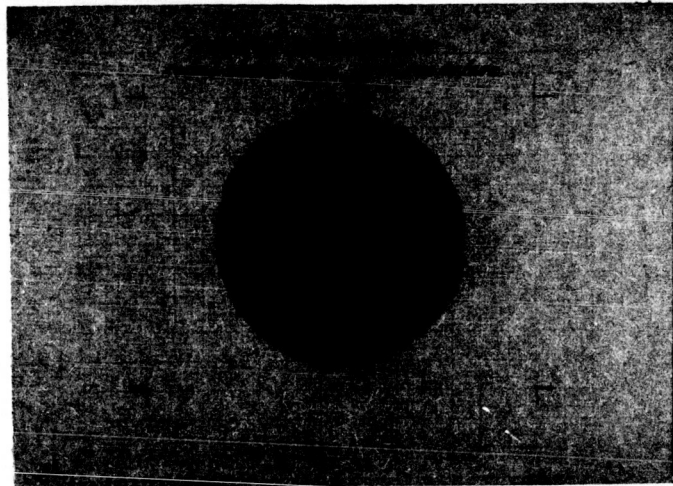
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# OPERATING RANGE

